Space Weather Technical Forecast

Issued on Friday, 29 December 2023 at 13:20 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of R1/Minor Radio Blackouts.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with C-class flares observed, the largest of which was a C9.8 from AR3533 at 29/0754 UTC. There are six sunspot regions on the visible disc. AR3529 is a large, stable region that is in the process of rotating around the southwestern limb and therefore its classification is conserved. AR3533 is currently the most active region, though appears rather simple now with an open structure. AR3526 has faded to plage. All the other regions appear stable. No Earth-directed CMEs have been observed in available imagery.

Solar Wind / Geomagnetic Activity: Solar wind parameters indicate the possibility of two weak CME arrivals, one around 29/0000 UTC and the other around 29/1200 UTC. Speeds initially increased to around 490 km/s ahead of the first CME arrival, then gradually declined to 370 km/s. Density rose from below average to above average, peaking at 19 ppcc around 29/1100 UTC. Total magnetic field strength, IMF, was largely weak but became briefly moderate on the arrival of each CME. The north-south component, Bz, has varied weakly throughout, with a greater proportion within the positive sector. Phi angle has been predominantly positive (away from the Sun). Geomagnetic activity was Quiet through the period.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was generally at background, but briefly marginally above due a far sided CME overnight. GOES16 high energy (greater than 2MeV) electron flux varied between background and moderate levels. The 24-hour fluence was below Active throughout on a predominantly flat trend. The 29/0000 UTC observation was 1.11e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low activity is likely to continue, with a chance of Moderate activity.

Solar Wind / Geomagnetic Activity: A CME is currently affecting the Earth, with only minor effects thus far, this was the last in a series of potential CMEs to arrive at Earth in the past 48 hours. Solar wind parameters should all decline back to background later on day 1 or by day 2 (29/30 Dec). Otherwise, a high speed stream from coronal hole 86 is forecast to connect with Earth either late on day 3 (31 Dec) or on day 4 (01 Jan), giving speeds of 450-550 km/s.

Geomagnetic activity will start Quiet to Unsettled with a chance of Active intervals and a slight chance of G1/Minor Storm intervals. Activity is then expected to decline to become predominantly Quiet through 30 Dec, but then a risk of further Active to G1/Minor Storm intervals late on 31 Dec or on 01 Jan due to the connection with the high speed stream.

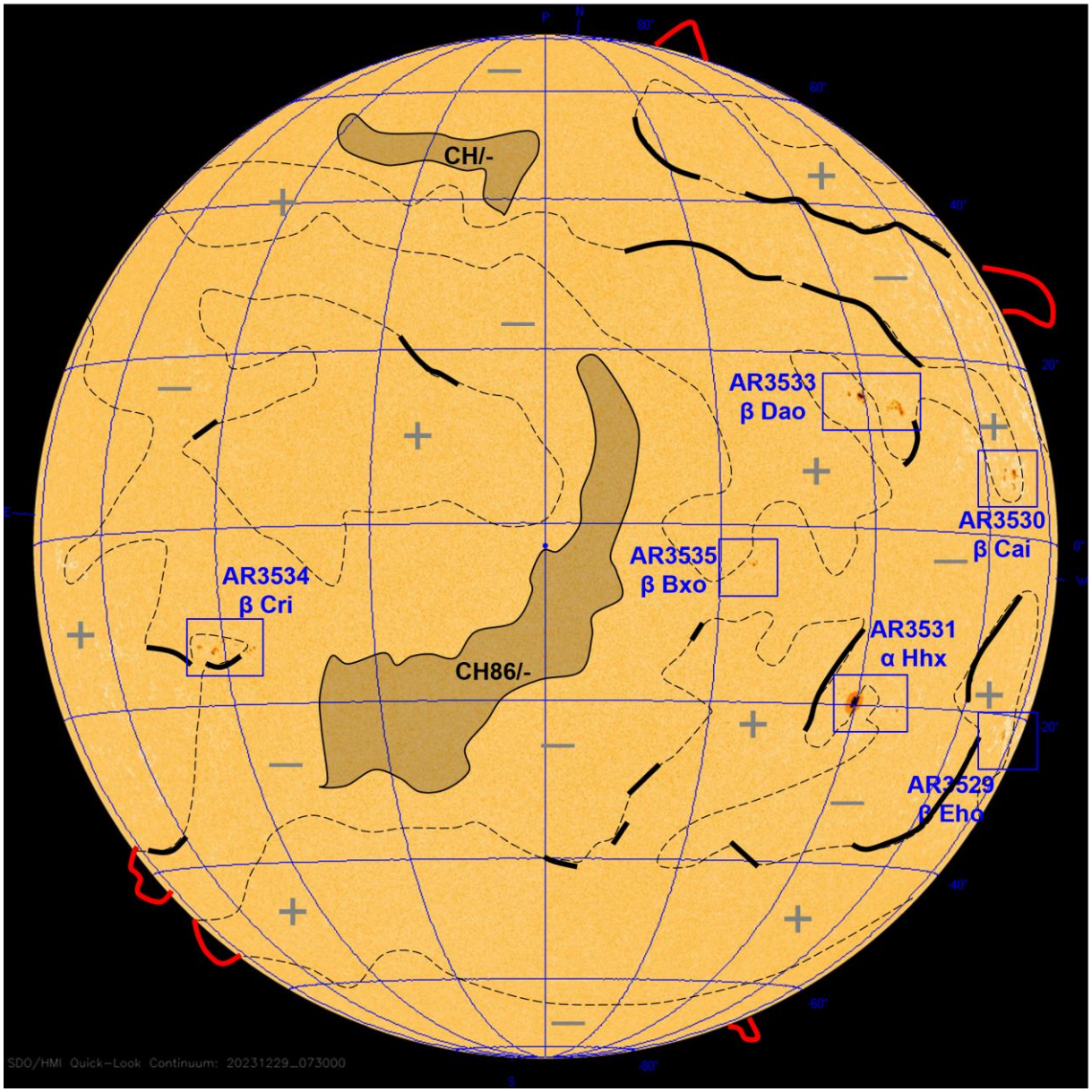
Energetic Particles / Solar Radiation: GOES16 high energy proton flux is at background and likely to persist at this level. There is a very slight chance of reaching S1 given any notable flares from regions rotating toward the western limb. GOES16 high energy electron flux is likely to remain at moderate or background levels initially, perhaps with a slight rise toward the end of the forecast period due to the high speed stream of coronal hole 86. Electron fluence levels will likely follow a similar trend, with a rise towards the end of the period towards the Active threshold

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

possible, but with a very low risk of reaching the threshold.

Figure 1. Solar Analysis Valid 29/0800 UTC



*.

Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

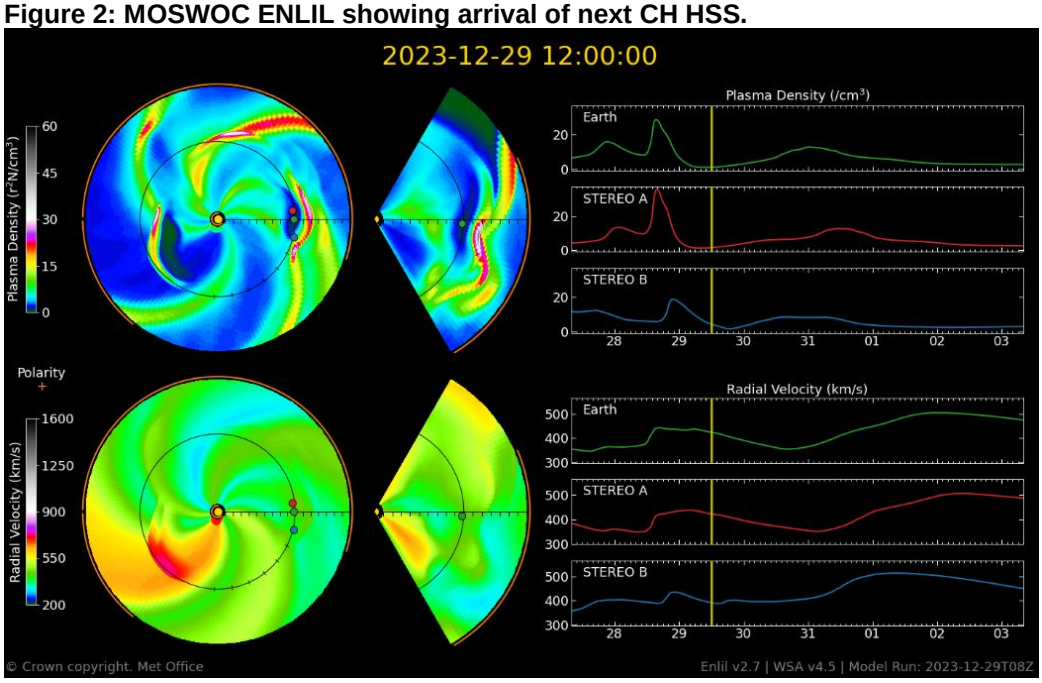
All CMEs from 24 and 25 Dec are now thought to have arrived at or missed Earth, with no further Earth-directed CMEs in the forecast.

Solar wind speeds are trending downward, with other parameters generally following suit, with all parameters expected to decline back to background later on 29 or on 30 Dec. The Earth may connect with the high speed stream from coronal hole 86 either late on 31 December or early on 01 January. This is a large, distinct returning feature with a high confidence of a connection, which produced speeds of around 500-600km/s on the last rotation. It is slightly smaller this time around, with speeds estimated to reach 450-550 km/s.

Starting Quiet, with a chance of Active intervals and a slight chance of G1/Minor storms due to residual CME effects. Activity is then expected to decline to become predominantly Quiet through 30 Dec. The coronal hole high speed connection with a possible preceding CIR (co-rotating interaction region) could give a slight chance of G1/Minor storms later on 31 Dec and into 01 Jan although geomagnetic responses are more muted close to the solstice.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	1	10	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: MOSWOC ENLIL showing arrival of next CH HSS.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

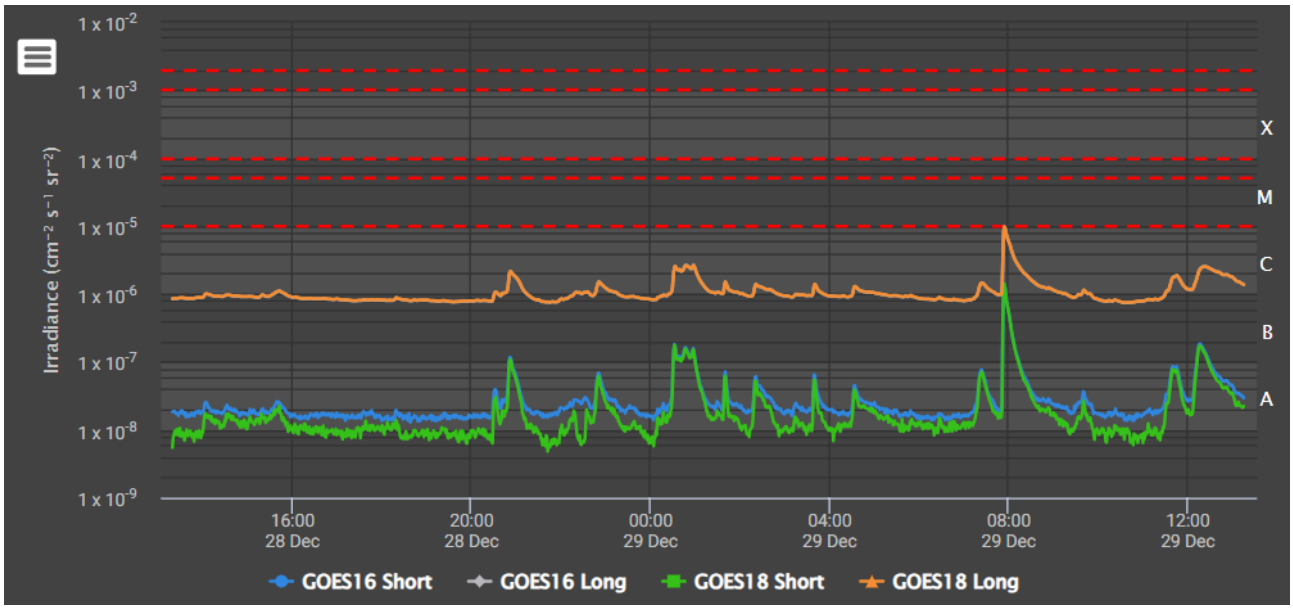
Radio Blackouts - X-Ray Flares:

There are six sunspot regions on the visible disc. AR3529 is a large, stable region that is in the process of rotating around the southwestern limb. AR3533 is currently the most active region, though appears rather simple with an open structure. AR3526 has faded to plage. All the other regions appear stable.

Solar activity is forecast to be mainly Low, with a chance of Moderate activity. Most sunspots on the Earth-facing disk reside on the western hemisphere, with up to four spots due to rotate off the disk during the forecast period. On the other hand, there appears to be up to three sunspots around the northeastern limb due to rotate on to the Earth-facing disk during the period, therefore forecast percentages are tentatively maintained during the next 4 days due to an expected balance of outgoing and incoming sunspots.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	30	30	30	30
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: 24 hour X-ray trace.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

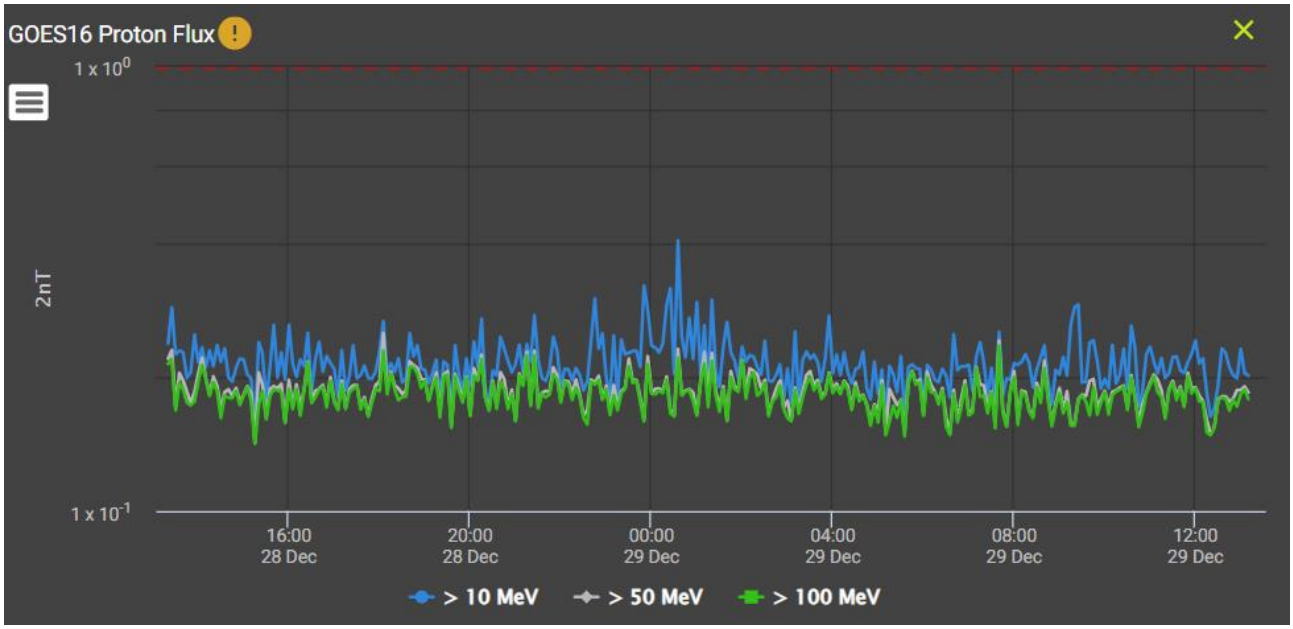
© Crown Copyright 2023. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

GOES16 high energy (greater than 10MeV) proton flux has been largely at background levels, with only minor perturbations observed in relation to a large far sided CME overnight. There is a very slight chance of proton enhancement if any further significantly energetic flare activity or Earth-directed CMEs were to be observed.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: 24 hour Proton trace.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

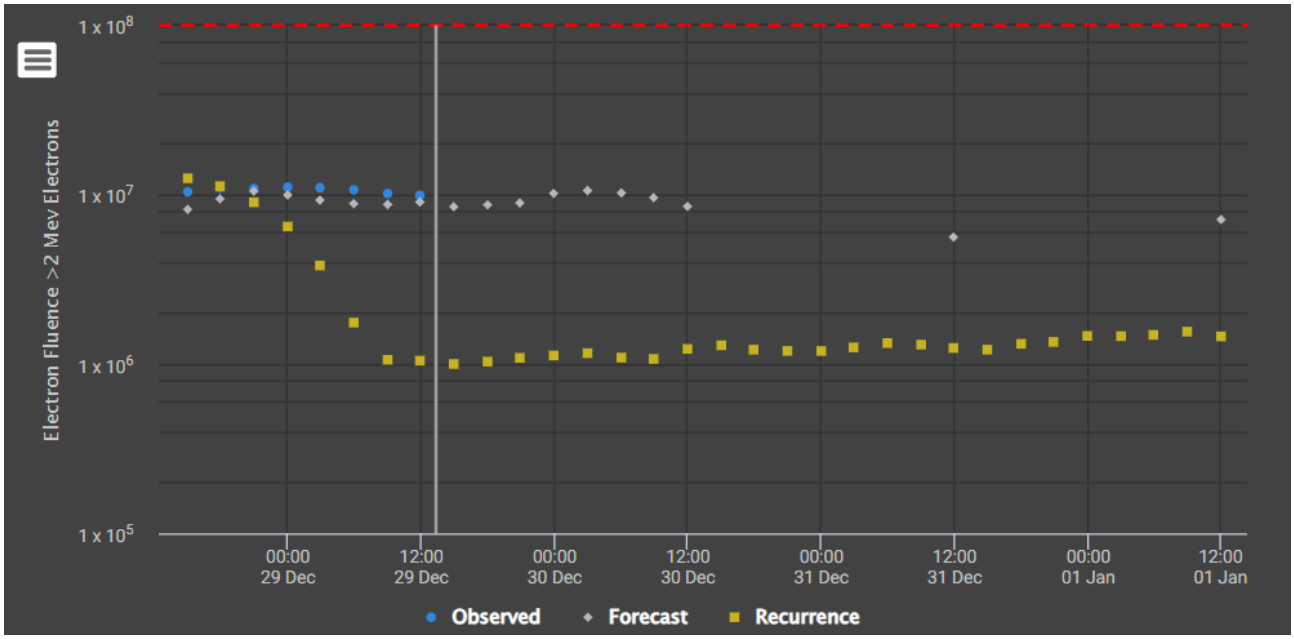
High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has varied between background and moderate levels. This is expected to largely continue, with any increase in flux likely to be modest. A more sustained increase is possible due to the high speed stream from coronal hole 86 during 01 Jan, following an initial high speed stream connection on 31 Dec.

Electron fluence is initially expected to show a steady trend, remaining below the Active (1e8 integrated pfu) threshold. A possible rise is then possible during 01 Jan in response to the increasing flux.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	1	1	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: MOSWOC REFM fluence forecast/observations/persistence.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.